graphs to illustrate the structure and mode of formation of the Paumotu atolls. Mr. Mayer has devoted much time to the drawing of the medusæ collected.

Judging from the temperature taken at various points, 40° F. seems to be found quite generally at about 500 fathoms depth.

We made a number of surface hauls, as well as intermediate hauls, with the townets, but obtained very little animal life. The poverty of the surface pelagic life, and down to 300 fathoms, is remarkable. I do not think I have ever sailed over so extensive an area as that of the Paumotus and observed so little surface life; on calm days, under the most favorable conditions, nothing could be seen with the naked eye, and at night there was little or no phosphorescence. Inside the lagoons our hauls were equally barren.

The same paucity of animal life seemed to extend to the deep-water fauna. All the hauls we made off the islands, in from 600 to 1000 fathoms, usually the most productive area of a sea slope, brought nothing, or so little that we came to grudge the time spent in trawling on the bottom, as well as towing on the surface or near it, a great contrast to the conditions of the Atlantic in similar latitudes, and very different from our anticipations. For these reasons no attempt has thus far been made to make a trial of the deep-sea pump while in such unproductive areas, and unfortunately while we were in the region of the equatorial current the weather conditions were not suited for a trial of the apparatus.

We expect now to coal and refit, and to leave for Suva via Tonga on the 15th of this month. A. Agassiz.

THE TWELFTH ANNUAL MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

I.

The Geological Society of America convened at 10 a. m., Wednesday, December 27th, in the large lecture room of Columbia University, Washington, D. C. President B. K. Emerson called the meeting to order and Dr. G. K. Gilbert delivered an address of welcome, to which the President responded. The following officers were then declared elected for the ensuing year:

President: George M. Dawson, Ottawa, Ont.; *First Vice-President:* Charles D. Walcott, Washington, D. C.; *Second Vice-President:* N. H. Winchell, Minneapolis, Minn.; *Secretary:* H. L. Fairchild, Rochester, N. Y.; *Treasurer:* I. C. White, Morgantown, W. Va.; *Editor:* J. Stanley-Brown, Washington, D. C.; *Librarian:* H. P. Cushing, Cleveland, O.; *Councillors:* W. B. Clark, Baltimore, Md., and A. C. Lawson, Berkeley, Calif.

The following new Fellows were also announced as having received election:

Irving Prescott Bishop, 109 Norwood Avenue, Buffalo, N. Y., Professor of Natural Science, State Normal and Training School; Emilo Böse, Ph.D. (University of Munich, 1893), Calle del Paseo Nuevo No. 2, Mexico, D. F., Geologist of the Instituto Geologico de Mexico; Arthur Starr Eakle, B.S. (Cornell, 1892), Ph.D. (Munich, 1896), University Museum, Cambridge, Mass., Instructor in Mineralogy and Petrography, Harvard University; August Frederick Foerste, A.B. (Denison, 1887), A.M., Ph.D. (Harvard, 1888, 1890); John Flesher Newsom, A.B. (University, Indiana, 1891), A.M. (Stanford, 1892), Stanford University, Calif., Associate Professor of Metallurgy and Mining, Stanford University; Samuel Lewis Penfield, Ph.B., M.A. (Yale, 1877, 1896), New Haven, Conn., Professor of Mineralogy, Sheffield Scientific School of Yale University; Charles Henry Richardson, A.B., A.M., Ph.D. (Dartmouth, 1892, 1895, 1898), Hanover, N. H., Instructor in Chemistry and Mineralogy, Dartmouth College; Arthur Brown Willmott, B.A., B.Sc. (Victoria University, Toronto, 1887), M.A. (Harvard, 1891), Toronto, Canada, Professor of Geology and Chemistry, McMaster University.

During the year the Society has lost by death four of its most distinguished Fellows, of whom two, Sir J. William Dawson and Edward Orton, have been presidents. The others were O. C. Marsh and Oliver Marcy. Memorials were read of all but Professor Marsh, whose biographer, Professor C. E. Beecher, was absent, and had

failed to send his manuscript. Extemporaneous remarks were made after the reading of each of the memorials, and they were often marked by deep feeling, as one after another of the former students of the departed scientists paid his tribute to his old teacher and friend. The first paper was then read as follows:

Physiographic terminology with special reference to land forms. By W. M. DAVIS, Cambridge, Mass.

The paper embraced a critical discussion and a definition of terms, mostly suggested within the last thirty years, for the description of land forms. The terms cycle, base-level and grade were considered in detail.

The general principle was advocated that terms should be based on observation and should express its results. The geographical cycle was urged as the basis. Instead of the old conceptions of destructional and constructional; initial, sequential and ultimate were suggested. It was urged that for 'base-level' as applied to the limiting conditions of the development of a river 'graded slope' be substituted—as base-level has now a variety of meanings. Other terms involving the syllables 'sequent,' such as consequent, obsequent, insequent, subsequent, etc., were suggested and defined. In discussion B. K. Emerson referred to the difficulty of remembering the distinctions in meaning among so many similar terms, a remark that struck a sympathetic chord in the minds of all teachers present.

Camas Land, a valley remnant. By GEO. OTIS SMITH and GEO. CARROLL CURTIS, Washington, D. C., and Boston, Mass.

A description was given of the remnant of an old valley on the eastern slope of the Cascade Mountains, in Washington (Mt. Stuart quadrangle). Camas Land owes its preservation above the circumdenudation to an intrusive sheet of diabase. A relief model of Camas Land was exhibited which made clear to all present the peculiar phenomena of the region and the rearrangement of the drainage. Discussion by W. M. Davis and M. R. Campbell ensued, which, however, would require the model to be intelligible to one not present.

Some coast migrations, Southern California. By BAILEY WILLIS, Washington, D. C.

The section of the California coast described extends from Point Sur to Piedras Blancas, between Monterey and San Luis Obispo. Formations constituting the Santa Lucia Range of the Coast Ranges were described, their relations to each other stated, and the corresponding migrations of the Pacific Coast were indicated with probability. A review of the observations of Fairbanks was presented.

It was shown that the oldest rocks constitute a series of metamorphic schists and that on these rest the Jurassic, Cretaceous, Miocene and Pliocene series. The schists are intruded by granite. Five thousand feet above the Pacific the Miocene beds are met dipping eastward and thinning out in that direction. This indicates a great land area which must have existed in the Miocene, where now is the Pacific ocean; 3000 feet above the sea, folded Pliocene strata occur. There are, therefore, two submergences indicated and great elevation and disturbances in comparatively recent geologic time.

Submerged forest of the Columbia River. By G. K. GILBERT, Washington, D. C.

At the Cascades the Columbia river flows over a natural dam of rock fragments. In the pond above stand sound stumps of Douglas spruce. Of various explanations proposed that first suggested by Lewis and Clark and repeated by Gibbs and Newberry accords best with the facts. The river was dammed by a land slide from the north not less than 350 years ago.

The speaker reviewed the explanations

of other observers and the Indian legends. He showed the general topography and geology by means of maps, and explained his estimate of the lapse of time by the rings in the stumps of trees which had grown on the landslide. There is also a river terrace about 100 feet above the present water level. The landslide therefore ponded the river and drowned the trees standing above it. In discussion J. A. Holmes cited cypress trees, in good preservation, 20 feet below the bottoms of rivers in North Carolina, and G. B. Shattuck spoke of similar cases in Maryland in the Pleistocene.

Physiographic development of the Washington region. By N. H. Darton, Washington, D. C.

A general sketch was presented, illustrated by maps and photographic illustrations, and intended to give visiting geologists an outline of the principal features of the Mesozoic to recent geology.

The paper was not meant for publication, but it served to set before the Society an excellent idea of the geological formations near Washington and their physiographic development.

Erosion forms in the Harney Peak District, Black Hills, South Dakota. By Edmund Otis Hovey, New York City.

The paper consisted of the exhibition of about ten lantern slides, showing the peculiar forms produced by erosion in the schists and pegmatites in the Harney Peak District in the Black Hills of South Dakota.

The slides illustrated the curiously sheeted and jointed granite which leads to the production of very rough topography. Pictures of the large spodumene crystals at the Harney Peak tin mines were also thrown upon the screen.

In discussion President Emerson compared the spodumenes with those of Massachusetts. S. F. Emmons described the occurrence of the spodumenes in pegmatites. I. C. Russell inquired if there were evidences of glaciation in the hills; Mr. Hovey replied, no. A. C. Spencer inquired if the Sylvan Lake was a rock-basin. This was likewise answered in the negative.

Topographic features of Ohio. By W. G. Tight, Granville, O.

The general topographic features of the different sections of the State were discussed and an attempt was made to show the reasons for the different types. The paper was illustrated with lantern views.

The author remarked the paucity of information about the physiography of the State in general. He divided it into three areas: the northwestern, within the limits of the glacial ice; the border, a belt along the terminal moraine; and the southeastern, outside the drift. The readjustments of drainage and the various topographic forms were admirably illustrated. In discussion M. R. Campbell inquired if there was good evidence of peneplains in the southeast; the author replied that there was some but that it was not conclusive. I. C. White discussed the general directions of the drainage.

Drainage modifications in Southeastern Ohio. By W. G. Tight, Granville, Ohio.

The changes in drainage of the region north of the Ohio river and between the lower Muskingum and the lower Scioto have been very great. The lower Muskingum, south of Zanesville, is shown to be a composite stream made up of sections of four preglacial streams which crossed the course of the present Muskingum. These four streams united in what is now the Little Hocking basin, and the main line of preglacial drainage extended across the present Hocking river, which is also shown to be composed of sections of several preglacial streams, into the basin of Raccoon creek and across this basin into that of the Scioto river below Chillicothe. Several of

the tributaries of this preglacial river were also described.

The paper gave a very graphic conception of the rearrangements which were brought about by the continental ice sheet, changing the outlet of the river system from the Great Lakes to the Mississippi. In discussion M. R. Campbell brought up the Teazes valley and the changes in the Big Kanawha, and the presence of silt in the former. W. G. Tight then described the area covered by silt and referred the readjustment of the drainage to the obstruction which it presented. The silting was explained by some barrier far to the westward. I. C. White referred to his early description of the valley, and urged the danger of mistaking, for cols, narrows in the Ohio and other rivers produced by the crossing of some hard stratum. The author replied that he had sought to guard against this.

The landslides of the Rico Mountains, Colorado. By WHITMAN CROSS, Washington, D. C.

The Rico Mountains, in southwestern Colorado, are due to the erosion of a local domatic uplift. The sedimentary formations affected embrace the Algonkian, Devonian, Carboniferous, Permo-Carboniferous, Juratrias and Cretaceous. Many intrusive dikes, sheets and small laccoliths of diorite—or monzonite—porphyry occur in this complex. A large monzonite stock penetrates all rocks above mentioned. Intense and complicated faulting has taken place in the heart of the uplift, and there has been a great amount of mineralization, forming argentiferous ore bodies of many types.

Landslides, occurring in a recent geological epoch, are very prominent features of the local geology. These landslide areas were described, the relation of the phenomena to other elements of the geological history were discussed, and hypotheses of their origin set forth.

The landslides are limited to the central portion of the domatic uplift. No apparent connection can be traced between the structure and the slides, nor are they present in the region of greatest faulting. The speaker finally concluded that they were connected with deep, interior vulcanism, transmitted through the intruded stock of monzonite.

J. B. Woodworth mentioned similar cases in southwestern Montana, where water-bearing beds caused the slipping. W. M. Davis mentioned Alpine cases where glacial erosion had removed the support. Dr. Cross said there was no glaciation at Rico. W. H. Niles also referred to Alpine cases. Geo. Otis Smith mentioned similar cases in the Stewart mountains, Oregon, where, of all the rocks present, the granite is alone unaffected.

A recent fault scarp in the Lepini Mountains, Italy. By W. M. DAVIS, Cambridge, Mass.

The Lepini mountain group is a submaturely dissected block of cretaceous strata, 40 miles S. E. of Rome. Recent movement on the line of a tertiary fault has produced a well-defined scarp in places 100–200 feet in height and traceable five miles or more along the northeastern base.

The paper was finely illustrated by the lantern and the truncations of fan-like projections of rock called rock-fans were well shown. There was no discussion. The reading of the paper closed the first day's proceedings.

On Wednesday evening the President, Professor B. K. Emerson, delivered his presidential address upon 'The Tetrahedral Earth and the Zone of the Intercontinental Seas,' before a large gathering of the Society and their friends. It will appear in another number of SCIENCE.

The Society convened in business session Thursday morning at 9.30 o'clock. The

report of the Council was submitted and approved. Reports were received from the photographic committee which shows that a collection of over 1900 views has been made. The committee then resigned and N. H. Darton was elected a committee of one to have charge of the matter. A motion was passed approving of the organization of a Cordilleran Section to embrace the members living on the Pacific coast, who by reason of distance cannot meet with the Society, and a telegram of greeting was sent to them in their first session.

The report of the Council showed the Society to be in a very prosperous condition. There are 239 Fellows, besides the 8 elected at this meeting. The Society has an invested fund of $5,000, and on account of an unavoidable delay in issuing Vol. X, had also a balance, December 1st, of $3,030.02. The Society is, however, very anxious and ambitious to increase its invested funds in order that the income may admit of the suitable illustration of papers.

Deposits of calcareous marl in Michigan. By Israel C. Russell, Ann Arbor, Mich.

A large number of lakes and swamps in the southern Peninsula of Michigan have been found to contain deposits of calcareous marl suitable for the manufacture of Portland cement. The marl is composed in part of shells, but is mainly a chemical precipitate and is still being deposited. The better grades contain from 80 to 95 per cent. of calcium carbonate. Several large cement works have already been established and others are contemplated. The supply of marls is practically inexhaustible and Michigan can easily take a leading place in the Portland cement industry.

The precipitation of the calcareous matter is probably due to the fact that calcium carbonate is more soluble in cold water than in warm, and as the lakes are fed by springs, the waters rise in temperature and lose their dissolved material.

J. F. Kemp referred to the importance of the industry and the previous efforts that had been made near Syracuse to utilize the same materials. J. M. Clarke emphasized the possible part played by algæ in precipitating the calcium carbonate. The speaker replied that he had not found much evidence of them.

Glacial origin of the older Pleistocene in the Gay Head Cliffs, with a note on the fossil horse of that section. By J. B. Woodworth, Cambridge, Mass.

The occurrence of glaciated fragments in the boulder bed at the base of the older Pleistocene (Columbia) in the Gay Head Section was described and illustrated, confirming, it is thought, the theory of the existence of an ice invasion long antedating the surface moraines of the New England islands. The astragalus of a mammal identified with that of a horse, by Professor Osborn, was exhibited. This bone was found in the Miocene underlying the boulder bed at Gay Head.

Beach structure in Medina sandstone. By H. L. Fairchild, Rochester, N. Y.

The papers involved an exhibition, by lantern slides, of structural features in the Medina which indicate shallow water and beach deposits. The speaker referred to the phenomena described by G. K. Gilbert at a previous meeting as giant ripples, which suggested waves of 60 ft. height. Many views were shown illustrating them, and small ripple marks were seen on these crests. Individual cases without parallel neighbors were exhibited. The phenomena were then interpreted by the action of actual waves on the beach of Lake Ontario and they were explained as due to shore-wave action. C. W. Hayes cited similar phenomena on the San Juan River, Nicaragua, and H. S. Williams described chan-

nel fillings in the Devonian beds near Ithaca, which threw light on the cases in point.

Glacial erosion in the Aar Valley. By ALBERT PERRY BRIGHAM, Hamilton, N. Y.

Observations were made between Meiringen and the Abschwung. The valley has several relatively broad and open sections, containing small rock basins. These basins are filled with alluvial material. One double basin, however, that of the Grimsel Lakes, being out of the track of the stream, keeps its water-filling. Between the basins, in some cases, are narrow V-shaped gorges, bordered by heavily glaciated spurs thrown out from the valley sides. The sides of the gorges are often glaciated nearly to the bottom. In other cases rock barriers have crossed the valley and are now breached by very narrow post-glacial gorges, as above the Grimsel Hospice and above Meiringen. Supplementary illustrations were given from the Rhone and Visp Valleys.

W. M. Davis in discussion illustrated the discordance between side valleys and the main valley—the former discharging at an altitude of some hundreds of feet above the floor of the latter. These discordant, lateral valleys were called 'hanging valleys.' I. C. Russell remarked the same phenomena in the Sierras and Cascades. Bailey Willis emphasized the excess of lateral erosion by glaciers over the vertical and that thus the natural grade of the side valleys had been truncated. W. H. Niles laid stress on the importance of subglacial streams, along the sides of a glacier. G. K. Gilbert urged the efficiency of glacial erosion and stated that the profiles of lateral valleys did not coincide with the idea of truncation. The discordance may be met in rivers, as along the Rio Virgin, where the main stream deepens faster than the laterals. J. J. Stevenson corroborated the same views by the valley of the Twin Lakes in Colorado. J. W. Spenser described the hanging valleys of Norway, which are step-shaped at the discordance. I. C. White described discordance along the Monongahela Valley, where no glacier had ever existed. S. F. Emmons cited hanging valleys along the Columbia River, where it crosses the national boundary. H. W. Turner mentioned cases in the Sierras in the Bidwell Bar quadrangle. A. P. Brigham confirmed the power of a glacier to erode. W. M. Davis closed the discussion.

Movement of glaciers. By HARRY FIELDING REID, Baltimore, Md.

The paper gave the results of from one to three years' observations on the movement of the Forno glacier, with special reference to the vertical component of the movement. The existence of surfaces of finite shear in glaciers was discussed. The author described the set of stakes that he had set up at several places across the glacier and had watched for two or three years. They showed a slow movement at the end and a more rapid one up the ice-stream, and some interesting relations at the névé. He proceeded at once to the reading of his second paper.

Stratification and banded structure of glaciers. By HARRY FIELDING REID, Baltimore, Md.

Careful work on a number of the Swiss glaciers has enabled the author to follow the outcrops of the strata from the névé-line practically to the end of the glacier, and has convinced him that the banded structure is the modified appearance of the outcrops. A reason is suggested why glacialists have held divergent views on this subject. With a beautiful and complete series of lantern slides the author illustrated the evidences of stratification and the phenomena of movement. He distinguished

stratification lines from the banding due to pinched crevasses and to other causes, and discussed the differences of Agassiz and Forbes regarding these phenomena. Bailey Willis commented on the close parallelism between ice movement and rock movement and inquired regarding the phenomena of movement. Dr. Reid replied that there was no shearing at all, but that plasticity sufficed to explain all the observed phenomena.

A channeled drumlin. By H. L. Fairchild, Rochester, N. Y.

A few lantern views showed a longitudinal hollow (channel?) in a drumlin terminating at the lower end by a transverse cut.

The phenomena had puzzled the writer and after illustrating them he appealed to the Society in vain for an explanation.

Distinction between Upper and Lower Huronian. By A. P. Coleman, Toronto, Canada.

During the past summer a band of rock consisting of fine-grained sandstone, chert or jasper, with interbedded iron ore, has been found at Michipicoton, on the northeast shore of Lake Superior, corresponding to the Vermilion and other iron-bearing series west and south of Lake Superior. This band has been traced for 30 or 40 miles, and has been recognized at various points to the west as far as Rainy Lake and east to Lake Temagami. It is the most easily determined member of the Lower Huronian. Many fragments of this sandy, cherty or jaspery rock are found, as well-rounded pebbles in conglomerates of the Upper Huronian, at Gros Cap, a few miles west of Michipicoton, and at other points as far west as Shoal Lake and east as Lake Temiscaming, a distance of more than 600 miles. Jasper and other pebbles of these rocks furnish an easily applied test of the Upper Huronian, since their materials can have come only from the Lower Huronian. The basal conglomerates near Thessalon and also on Lake Temiscaming contain jasper pebbles, and hence indicate only the base of the Upper Huronian. This far-reaching break between the two parts of the series represents a great lapse of time, as proved by the Shoal Lake conglomerate.

In discussion C. D. Walcott disclaimed any conflict in the meaning of Algonkian and Huronian, making the former a much wider and more inclusive term than the latter.

The Cambrian formation in the Atlantic province. By Charles D. Walcott, Washington, D. C.

The work of Dr. G. F. Matthew and the use of the term Etcheminian series, by him, for a sedimentary series formerly considered to be pre-Cambrian and to be separated by a break from the Cambrian, was reviewed. The presence of a stratigraphic break between the Etchenimian and Cambrian was found not to exist. The apparent break is explicable by folds. The same relations were found in Newfoundland. Views were shown illustrating the Smith's Bay and Manuel's Brook localities.

The Lower Devoniun aspect of the Lower Heidelberg and Oriskany formations. By Charles Schuchert, Washington, D. C.

The Silurian of Murchison was compared with the American equivalents. The Devonian of Sedgwick and Murchison has no marked Lower Devonic fauna. The Lower Devonic of Germany was summarized. The Helderberg fauna is transitional to the Oriskany, and these two constitute the American Lower Devonic.

The paper was read by J. M. Clarke and the next three titles were taken up before discussion was begun.

The Silurian-Devonian boundary in North America. By Henry S. Williams, New Haven, Conn.

The writer presented a discussion (*a*) of the principles to be used in determining the

boundary between the two systems, Silurian and Devonian, the standard sections of which are on another continent, and (*b*) of the facts of correlation bearing upon the case.

He urged that to establish the top of the Silurian as the word was used by Murchison, we must find the equivalent of the Tilestone fauna. This has been done in the Arisaig fauna of the Maritime provinces, which is well developed in northern Maine and which lies over the Helderberg fauna at the same place. He therefore developed an argument for retaining the Helderberg in the Silurian.

The contact of the Silurian and Devonian in Erie Co., N. Y. By A. W. GRABAU, Troy, N. Y.

A limestone known as the Bullhead rock was found to contain fossils like those described by Whitfield from the Helderberg of Ohio. There is an unconformity between the Bullhead rock and the overlying Onondaga. A sandstone dike in a crevice in the limestone was described and some suggestions regarding the choice of a name for the Bullhead rock were made. The Manlius limestone was finally adopted, it having been used by Dr. J. M. Clarke.

Devonian strata in Colorado. By ARTHUR C. SPENCER, Washington, D. C.

The presence of Devonian rocks in southwestern Colorado, asserted by F. M. Endlich in 1874, has been confirmed by observation of the United States Geological Survey party under the direction of Dr. Whitman Cross.

The section when complete is threefold, consisting of a conglomerate and sandstone at the base, followed by a calcareous shale, and this by a massive limestone containing considerable numbers of invertebrate fossils. The limestone is shown by its outcrops to have covered an area of at least 600 square miles. The sandstone and shale beds are locally absent through non-deposition. Their age is possibly Silurian, though they contain occasional fish remains, which would ordinarily be considered indicative of the Devonian. The silicious series is correlated with the 'Parting Quartzite' of central Colorado, and mention is made of further probable equivalency between this series and the supposed Devonian of the Grand Canyon region. This brings out the probability that these formations of the Middle Paleozoic were originally deposited over a very extensive area in the southern Rocky Mountain region.

The fossils have been studied by Dr. George H. Girty, who considers that they are representative of a fauna older than that of the Chemung, and probably belonging at the base of the upper Devonian or near the top of the lower. Collections made by various geologists in central Colorado, are found to contain the same assemblage of fossils and to afford a basis for correlation. The fauna resembles that described by Whiteaves, from Hay River, Canada.

All four Devonian papers were discussed together. J. M. Clarke urged, regarding the delimitation of the Silurian, that it should rest upon the organic forms and their culmination, and not on the classification of Murchison. He then emphasized the Devonian aspects of the Helderberg of New York most strongly, and stated that its rich fauna should decide the question and with it the Arisaig would go. Dr. Clarke also corroborated the observations of Grabau by his own studies in the cement quarries of Buffalo.

H. S. Williams stated his method of solving the Devonian question as an endeavor to find in America an equivalent section to the classic section of the Old World. He therefore had searched for it in Maine and had discovered one above the Helderberg, which was almost exactly equivalent to the Tilestone. Other con-

trasts were instanced. C. H. Hitchcock remarked the importance of northern Maine as a place to decide this question, and mentioned Lake Telos as a promising locality. H. S. Williams again spoke, bringing up the Gaspé section and mentioning facts about northern Maine. J. M. Clarke also remarked his acquaintance with the Devonian fossils from Maine and reaffirmed the finality of the organic tests of correlation.

These papers concluded the session of Thursday. In the evening at 7.30 o'clock the Society assembled at the Hotel Raleigh for the annual banquet. To the delight of all present, Professor Emerson was found at the head of the table, and as usual a very merry evening followed. According to the admirable custom, now well established, the fellows brought their wives, and the ladies gave a brilliant aspect to the dinner. Ninety-five covers were laid, including about 15 for ladies.

J. F. Kemp.

Columbia University.

SCIENTIFIC BOOKS.

Frontinus and the Water Supply of the City of Rome. By Clemens Herschel, Hydraulic Engineer. Boston, Dana Estes & Co. 1899. 4to. xlix + 296 pages.

Frontinus was appointed water commissioner of Rome in 97 A.D., and soon thereafter wrote his two books, generally called De Aquis, on its waterworks. The sole original Latin manuscript, dating from the twelfth or thirteenth century, is preserved in the library of a Benedictine monastery in Italy, and the photographic reproductions of its twenty-four pages which Mr. Herschel gives will be of interest to classical scholars. He also gives the Latin text and its English translation on facing pages, and adds twelve chapters of explanatory and critical matter which are of special value to civil engineers and archæologists; these are accompanied by eighty-four illustrations and three folding plates. This is the first time that De Aquis has appeared in English translation, and it is safe to say that no single volume has ever been published that contains such a wealth of information on the water supply of ancient Rome.

The treatise of Frontinus begins with a description of the nine aqueducts erected prior to 97 A.D., mentioning their builders, sources and lengths. The subject of water measurement is next discussed and the sizes of the standard pipes are given, this being preparatory to determining the amount of water furnished by each aqueduct and how much was used for fountains, for public buildings and for private uses. Then the quality of the waters and the laws for the prevention of pollution receive attention, and this is followed by a statement of the duties and powers of the water commissioners, and of the regulations for preventing the unlawful use of water. Lastly, the methods of repairing the aqueducts are discussed, and the laws for ensuring their proper maintenance are given.

Mr. Herschel discusses at length the engineering and hydraulic feàtures of the aqueducts and of the methods of distributing the water. It is clearly shown that the Roman engineers had no rational methods of measuring water, such quantities as cubic feet per second or gallons per hour being beyond their powers of conception. The unit of measurement used by them was called a 'quinaria,' this being originally a circular pipe whose diameter was $1\frac{1}{4}$ Roman digits, later the number of square units in the cross-section of this circle, and later the quantity of water passing through this area. Evidently it was understood that the discharge through a pipe or channel would vary with the velocity, as Frontinus says that the aqueduct Virgo could not be properly measured near its source, where the current was too slow, but near the city where the velocity was greater he found it to give 2504 quinarias. In general, however, the measurement of water was made by finding the area, in quinarias, of the cross-section of the channel or pipe; thus a denaria pipe, whose diameter was double that of the quinaria pipe, was supposed to discharge four quinarias of water.

The statement is commonly made in cyclopædias that the aqueducts of ancient Rome delivered about 300 gallons of water per day for